(3 Hours) **[Total marks: 80]**

N.B.: (1) Question No 1 is compulsory
(2) Attempt any three questions out of remaining five questions
(3) Assume suitable data if necessary and indicate it clearly.
(4) Figures to the right indicate full marks.

Q.1. Solve any four questions of the following. **20**

(a) What are basic design steps of process design?
(b) Explain six tenth rule and its application for cost estimation of equipment.
(c) What are Annuities and Perpetuities?
(d) What is schedule number? How optimum pipe diameter can be determined?
(e) Explain FUG method to design distillation column.

Q.2. (a) What is Retrofitting? What are the various motivations for retrofitting? Why Contingency is added to process? **10**

(b) Benzene at 37.80 C is pumped through the system at a rate of 9.09 m^3/h with the help of a centrifugal pump. The reservoir is at atmospheric pressure. Pressure at the end of discharge line is 345 kPa g. The discharge head is 3.05 m and the pump suction head is 1.22 m above the level of liquid in reservoir. The friction loss in suction line is 3.45 kPa and that in the discharge line is 37.9 kPa. The mechanical efficiency of the pump is 0.6. The density of benzene is 865 kg/m^3 and its vapour pressure at 37.80 C is 26.2 kPa. Calculate (a) $(NPSH)_A$ and (b) power required by centrifugal pump. **10**

Q.3. (a) The original value of a piece of equipment is Rs 27,000 completely installed and ready for use. Its salvage value estimated is Rs 2000 at the end of its service life of 10 years. Determine the asset value of the equipment at the end of 5 years using: **10**

i. Straight line method
ii. Decline Balance method
iii. Double Decline balance method (200%)

(b) It is desired to borrow Rs.5 lakhs to make a financial obligation. The money can be borrowed from loan agency at monthly interest rate of 2 %. Determine the following **10**

i. Total amount of Principal plus simple interest due after 2 years if, no intermediate payments are made?
ii. Total amount of Principal plus compounded interest due after 2 years if no intermediate payments made?
iii. Nominal interest rate when interest is compounded monthly.
iv. Effective interest rate when interest is compounded monthly.

Q.4. (a) 95% of acetone is to be recovered from acetone-air mixture containing 10 gmol/s air and 1 gmol/s acetone by absorption column using water as a solvent at 300 K and 10 bar. Absorption factor for acetone is 1.4 **10**

Data:

Components	Vapor Pressure (bar) at 300 K
Acetone	0.331
Water	0.035

Find required flow rate of solvent, theoretical number of stages and composition of leaving vapor and liquid streams of absorption column.

(b) Explain 12 step the design procedure for design of distillation column. **10**

Q.5 (a) Find out area of heat exchanger according to the following specifications and calculate the total installed cost (updated bare module cost) in year 2020. **10**

Heat exchanger specifications:

Identification = condenser

Function – to condense overhead vapor from methanol fractionating column

Type – horizontal fixed tube sheet, expansion ring in shell.

Heat duty – 896 kW, U (overall heat transfer coefficient = 851.7 w/m^2K

Type of flow – counter current

Tube side and Shell side specifications:

Tube Fluid – cooling water , T_{in} = 25^0C, T_{out} = 35^0C

Shell Fluid – methanol, T = 70^0C (constant)

Shell material – Carbon steel, Tube material – Carbon steel

Pressure factor Fp= 0.2

Cost index of base year =391, Cost Index 2020 = 411

Equipment type	Co (Rs.)	So (m^2)	Range(S) (m^2)	α	MF
Heat Exchanger	$25x10^4$	37.18	10 – 900	0.65	3.29
	$1.5x10^4$	0.51	0.1 – 10	0.024	1.83

HEx Design type	Kettel reboiler	U tube	Fixed tube sheet
F_d	1.35	0.85	0.80

Heat Transfer Area (m^2)	Shell and tube material (F_m)	
	CS/CS	SS/SS
0 – 10	1.0	2.50
10 – 50	1.0	3.10

(b) What is capital cost? Explain various types of capital cost estimates. **10**

Q.6. (a) Explain shortcut methods of sizing of pumps and compressors. **10**

(b) A company is looking at 4 machines: **10**

	Type A	Type B	Type C	Type D
Initial cost (Rs.)	100000	160000	200000	260000
Operating cost (Rs.) /Year	1000	1000	1000	1000
Fixed charge % of initial cost (Rs.) /Year	20	20	20	20
Cash flow (Rs.) /Year	41000	63000	73000	88500

Company wants at least 15% returns, and only one design can be accepted, which design would you recommend? Use any suitable method of profitability analysis.

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